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GREEN CONSTRUCTION: U.S. CONSTRUCTION RELATED COMPANIES' STATUS AND PERCPETION

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ABSTRACT: This study reveals the status, perceptions, and future directions associated with green building within construction-related companies. A survey research method was used to capture current experience levels and capabilities of companies with regard to green construction. Expectations and perceptions about the future of the construction industry with regard to green building were obtained from construction-related companies recruiting from the Myers-Lawson School of Construction at Virginia Tech from 2006 and 2008. The findings of this study support the growing importance of green building as a component of the whole construction market and provide a benchmark against which to measure future changes in the industry over time.

Keywords: Green Building, Contractors' Perception, Construction Industry, Green Building Education

1. INTRODUCTION

The construction industry and its activities substantially impact our environment and health throughout the life cycle of a project from initial work on-site through the operational period and to the final demolition when a structure comes to an end of its life [1-7]. Environmental concerns include ozone layer depletion, global warming, acidification potential, smog, solid waste, ecosystem destruction, air and water pollution, and natural resource depletion, all of which are of increasing importance in our daily life [2, 4-9]. Due to these concerns, "sustainable construction" and "green building" along with the concept of sustainability are considered as a potential approach in the construction industry to minimize these concerns and increase potential social and economic benefits. In this study, green building is used to encompass many similar terms of sustainability in the built environment such as ecological design, ecologically sustainable design, sustainable design, and sustainable construction.

Green building can be defined as "healthy facilities designed and built in a resource-efficient manner, using ecologically based principles" [4]. Green buildings protect and conserve water; optimize energy performance; reduce environment impact of materials; and enhance indoor environmental quality by integrated design or green design [4, 11]. In addition, green building can also appropriately use land and landscaping and minimize the life cycle effects of a building's design and operation [4].

Due to these benefits, construction participants including contractors, sub contractors, architects, engineers, and owners have actively participated in this paradigm change not only to increase market share or profit but also to contribute to an environmentally friendly society [12, 13]. In addition, the demand for green building has also reshaped the design process into an integrated approach and significantly changed the role of the contractor [12]. Because of those paradigm shifts for construction participants, there is a need to benchmark the status of green building in the construction industry, especially for contractors. In a previous study, the authors collected data from construction participants, analyzed the collected data, and identified the current status of green building in the construction industry in the United States in 2006. The outcomes of that study were published in the Journal of Green Building with the title of "Green Construction: Contractor Experiences, Expectations, and Perceptions". However, due to rapid change of status of green building in the construction industry, the current study collected additional data from construction participants using an identical instrument to evaluate changes in status of green building in the construction industry.

2. BACK GROUND OF GREEN BUILDING

Instrument questions used in the current and previous study were developed on the basis of a literature review in the areas of construction activities and their impacts on environment; sustainability; green construction and green building; green building practices.

2.1 Construction Activities and Its Impacts on Environment and Health

Activities over the facility life cycle including design, construction, operation, maintenance, and demolition substantially impact environment and health. According to Ding [2, 14], construction activities affect the environment throughout the life cycle of a development from initial work on-site through to the operational period and through final demolition. Those environmental impacts caused by construction activities have been well

documented in the literature [2, 4-6, 15-18]. Major environmental impacts include global warming, climate changes, ozone depletion, soil erosion, desertification, acidification, loss of diversity, land pollution, water pollution, air pollution, depletion of fisheries, and consumption of resources such as fossil fuels, minerals, and gravel [2, 4-6, 15-18]. Specifically, in the United States, buildings account for 72% of electricity consumption; 39% of energy use; 38% of all carbon dioxide emissions; 40% of raw material use; 30% of waste output (136 million tons annually) and 14% of potable water consumption [3, 5, 19, 20].

The quality aspects of buildings such as indoor air quality, lighting, and thermal comfort are strongly related to occupant health, comfort, and productivity [21]. Measuring the exact financial impact of healthier, more comfortable building is difficult. The cost of poor indoor environmental and air quality – including higher absenteeism and increased respiratory ailments, allergies and asthma – are hard to measure and have generally been "hidden" in sick days, lower productivity, unemployment insurance and medical costs [21]. According to Fisk et al. and Kats [21-23], potential U.S. annual savings or productivity gain from improvements in indoor environments were in the range of $43 billion to $236 billion.

2.2 Sustainability

The concept of sustainability has gained popular momentum over the last twenty years starting with the publication of "Silent Spring" by Rachel Carson in the early 1960s [24]. The concept was widely recognized in 1987 with the definition of sustainable development developed by Brundtland Commission on Environment and Development [10]. Since this time, Agenda 21, a comprehensive program of global action in all areas of sustainable development, was developed at the Earth Summit held in Rio de Janeiro in 1992 by the United Nations Conference on Environment and Development [25]. After these events, the concept of sustainability penetrated into many areas with four basic emphases: eliminate poverty and deprivation; conserve and enhance natural resources; incorporate the concepts of economic growth and social as well as cultural variations into development; and integrate economic growth and ecological decision-making [10].These four aspects are directly related to construction activities due to the significant impacts on our environment and health.

2.3 Green Building Practices in Construction

To integrate the concept of sustainability into construction activities, the green building movement was initiated as a response of the construction industry to the environmental and resource impacts of the built environment [4]. Green building is a process to create facilities while considering environmental responsiveness, resource efficiency and cultural and community sensitivity [26, 27]. From implementing green principles in the construction industry, it is possible to achieve many benefits such as environmental, economic and health and community including improving air water quality, conserving natural resources, reducing operating costs, improving air, thermal and acoustic environments, etc. [4, 6, 11, 20, 21].

To achieve these benefits, the construction industry has implemented many green building strategies and technologies for green building design, green construction, green building operation and maintenance and even green demolition [4, 6, 11, 28]. In the construction industry, a widely accepted approach for implementing green building is to adopt green building rating systems such as Leadership in Energy and Environmental Design (LEED), Green Globes etc. [4, 13, 29]. Among these rating systems, LEED developed by the U.S. Green Building Council (USGBC) is the single most widely accepted green building rating system in the U.S. [12].

The penetration of green buildings in the construction market can be identified by reviewing the number of registered and certified green buildings in the United States. According to the USGBC, there has been a steady increase of LEED registered projects from 2000 to 2006, and registered projects substantially increased from 1,697 in 2006 to 5,358 in 2007 and 8,962 in 2008 (Figure 1). Along with the increase of LEED registered projects, the gross SF of LEED registered projects also follow the equivalent pattern with 1,985 million SF in 2008.

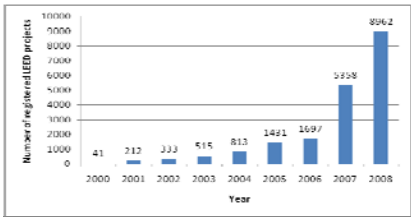

Figure 1. LEED Registered Projects [30]

Furthermore, the number of members in the USGBC also grew steadily in the first five years and then expanded rapidly over the last nine years to exceed 18,800 members as of February 2009. This growth of members and the number of LEED registered projects reflect the expansion of green buildings in the construction market.

According to the 2009 Green Outlook published by McGraw Hill Construction, in 2005, green building was a small, burgeoning market, approximately 2% of both nonresidential and residential construction, valued at a total $10 billion–$3 billion for nonresidential and $7 billion for nonresidential. Since that time, green building has expanded rapidly due to a number of factors such as growing public awareness of green practices, heavy increase in government interventions, and recognition by owners of the bottom line advantages. In fact, the value of green building starts was up five times from 2005 to 2008, with values escalating from $10 billion to $36 - $49 billion. In addition, the report estimates that green

building construction starts could triple over the next five years and reach $96 - $140 billion [31].

In addition, governments at federal, state, and local levels have enacted legislation such as Energy Policy Act of 2005 (EPACT 2005) and Energy Independent and Security Act of 2007 (EISA 2007), officially released Executive Orders by the President such as EO 13423- "Strengthening Federal Environmental, Energy, and Transportation Management" and developed green building guidelines for constructing new public buildings and managing existing ones [32-35]. In addition, many governments have allowed different types of incentives including tax breaks, expedited permitting, grants, fee reduction or waiver, density bonus, free consultation or promotional services, and financial incentives [36]. These incentives on the state and local level motivate developers and owners to implement or develop green building.

Finally, many professional and trade organizations including the American Institute of Architects (AIA), Associated General Contractors (AGC), National Association of Home Builders (NAHB), USGBC, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRA) and American Society of Civil Engineers (ASCE) have made considerable efforts towards supporting green construction including publishing educational materials, and developing guidelines and resources such as the AIA Environmental Resource Guide and ASHRAE GreenGuide [37, 38]. Other activities include creating training programs, hosting green building conferences, contributing to green building rating systems such as LEED, sponsoring research such as ASCE's Practice, Education and Research for Sustainable Infrastructure (PERSI) program, and making national awards for exemplary green buildings [13, 26, 29, 37, 39-41].

With strong momentum of green building in the construction industry, construction participants have adopted this paradigm change not only to increase market share or profit but also to contribute to an environmentally friendly society. Due to the importance of this concept in the construction industry, it is necessary to identify the current status of green building for contractors and the trend of green building in the construction industry.

3. OBJECTIVES AND RESEARCH SCOPE

The main objective of this study was to identify the green building experience and capabilities of construction companies, their expectations for green building knowledge and skills from new hires, mainly graduates, and the future of green building in the built environment from a construction-related company's perspective. This main objective was achieved by conducting a survey using the instrument developed by the authors in 2006; collecting data from construction participants that participated in the Virginia Tech's career fair in 2008; and developing simple descriptive statistics.

The developed instrument was divided into four sub-sections to support the main objectives, including: (1) understanding the profile of each company and its specific respondents; (2) examining the current situation of green building in the daily business of each company; (3) examining the importance of sustainability in construction education versus other skills and knowledge required by these companies, and (4) examining expectations and perceptions these companies have about the impact of green building on corporate practice in the future.

3.1 Research Scope

The instrument was restricted in distribution to construction-related companies including general contractors and subcontractors. These companies regularly visit the Myers-Lawson School of Construction at Virginia Polytechnic Institute and State University to recruit construction students for their internship and permanent positions. Even though many of these companies are focusing their business in the Commonwealth of Virginia, the State of Maryland, and the District of Columbia, several companies are doing business not just in the United States, but also all over the world. Many of these companies are also interested in construction curricula and knowledge of construction students in the construction program because the construction program educates their future new employees and future construction leaders.

In this study, the authors assumed that the knowledge of an individual respondent was representative of company philosophy and goals related to green building, and that respondents' answers accurately represented the company by which they were employed.

4. RESEARCH METHODS

Survey research was the main research method used to accomplish the research objectives. This section describes how the study: (1) selected sample companies working in the construction industry; (2) developed the survey instrument; (3) collected data; and (4) analyzed the collected data.

4.1 Sample Selection & Distribution

The population being studied here was companies doing business in the construction industry and actively participating in a construction career fair at Virginia Tech to recruit new employees and interns as well as to introduce their companies. The instrument was distributed to companies at the fall 2008 Construction Career Fair and Interviews at Virginia Tech on October 30 and October 31, 2009. The developed instrument was distributed to each company and collected at the end of the job fair. In this study, 88 questionnaires were distributed.

4.2 Instrument

In the instrument used in this study, questions were designed to conform to four basic structures: (1) open-ended, (2) close-ended with ordered choices, (3) close-ended with unordered choices, and (4) partially close-ended. The instrument used in this study was developed by authors in 2006 to conduct the study of "Green Construction: Contractor Experiences, Expectations, and Perceptions" published in the Journal of Green Building. Therefore, the content and format of the developed instrument was simply reviewed by authors before distributing to the sample population.

4.3 Data Collection

Among 88 companies, 36 questionnaires were collected at the end of the career fair. In addition, 16 questionnaires were mailed or emailed to the authors in a few days. Therefore, a total of 50 questionnaires was collected and the total response rate was 56.8%. However, seven of the collected questionnaires had missing data for many questions and were not analyzed in this study. The final response rate of this study is 48.8 %. These data were analyzed to accomplish the objectives of this study.

5. ANALYSIS OF SURVEY RESPONSE

The analysis started with analyzing demographic information of companies and respondents. This demographic information gave researchers many opportunities to conduct comparison analysis for specific questions. The first question was to ask career fair attendees about the type of their business. From Figure 2, general contractors were major respondents of this study (81%) with a small number of subcontractors, engineering companies, consulting firms and developers. Due to the business type, the outcomes of this study represent mainly a contractor's perspective of green building.

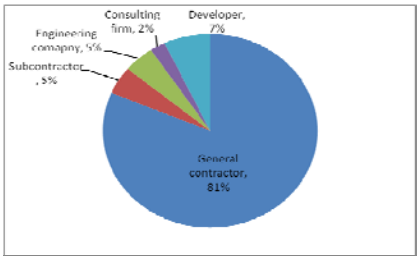

Figure 2. Type of business

The second demographic data was the annual business volume and the number of employees of respondents who participated in this study because it helped the authors to identify green building perspectives on the basis of the size of organizations. From Figure 2, the major respondent group with respect to the number of employees was the range of 101-500 employees with 19 respondents, and other groups were uniformly distributed between 3 to 6 in each category. In addition, the major respondent group on the basis of annual business volume was the range of $101 million to $250 million. However, there were nine companies whose annual business volumes were over $1 billion.

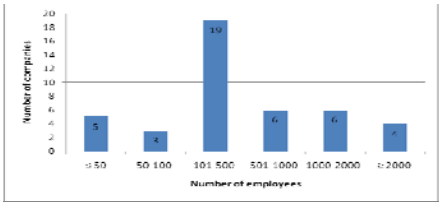

Figure 2. Number of employees

The job title or position of respondents is very important because each respondent represents green building practices of their company. From Figure 3, sixty five percent of respondents were project managers, vice presidents, presidents, and directors of the companies. Due to their higher position in each company, it is possible to assume each respondent as a representative of their companies. In the category of others included a technology engineer, a sustainability program manager, and a green building coordinator.

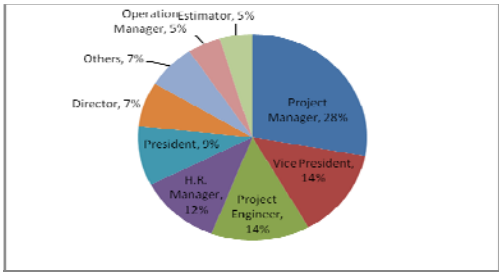

Figure 3. Title of respondents

Two questions were asked to measure the level of knowledge related to green building. One question asked whether the respondent was a LEED Accredited Professional (AP), which distinguished building professionals with the theoretical knowledge and skills to successfully steward the green design and LEED certification process [11, 13, 26]. The other question was the self-assessment of the level of knowledge related to principles of green building, ranging from "No Idea" to "very familiar". Six out of 43 respondents were a LEED AP and 88% of respondents (Figure 4) indicated that they were at least familiar with green building. The familiarity of green building for construction companies has increased from 2006 to 2008, with only two percent of respondents indicating that they were "not familiar" compared to eleven percent of respondents in 2006 (Figure 4). These outcomes also correlated to a dramatic increase of the number of LEED registered and certified project and the business volume of green building from about $10 billion to $36 - $49 billion [31].

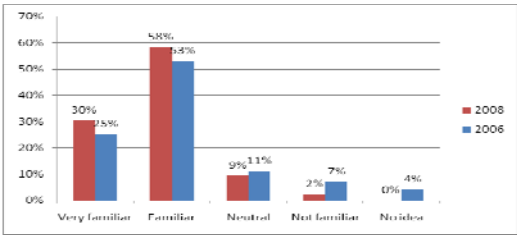

Figure 4. Familiarity with green building

5.1 Green Building Experience and Capability

The second part of the instrument was related to experience and capabilities of the company itself with green building. The first question was the exposure of the company to LEED projects because currently, green building rating systems were gaining popularity and have been widely used for green building in the United States to evaluate the sustainability of built facilities [29, 42]. The response (Figure 5) indicated that 84% of responding companies already had experience with green building in their business; five percent of respondents had bid or attempted to obtain a green building project but were not awarded the project; and eight percent of the respondents planned to get into the green building market in the future. Only three percent of the respondents replied that they were not interested in the area of green building. This outcome also supported the strong momentum of green building in the construction industry because of increase of green building experience from 2006 (Figure 5).

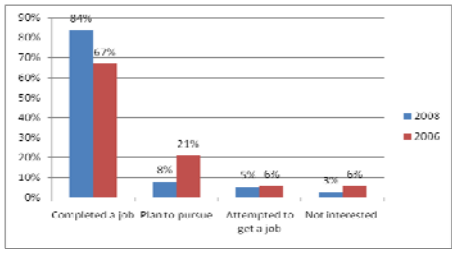

Figure 5. Exposure to green building (LEED) projects

As many companies have been involved in green building projects, the next question was how to obtain green building knowledge and skills to support green building projects and initiatives. The question was composed as a closed-end question with multiple-choice which the respondents could pick the best answer or answers from among all the possible options. The response (Figure 6) indicated that conducting internal research and reading trade publications related to green building were the most widespread ways for companies to get green building knowledge and skills. Other widely used strategies for finding necessary knowledge and skills were sending people to green building conferences and hiring consultants. Other ways to get green building knowledge included inviting green building experts to have green building training workshops and hiring an architect or LEED AP who was knowledgeable in the areas of green building. Compared to the outcome of 2006 (Figure 6), the respondents have been increasing their preference for internal research and hiring green building consultants and decreasing attendance at green building conferences.

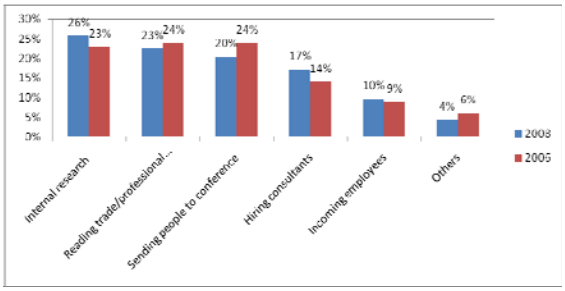

Figure 6. Sources of green building knowledge

The next questions targeted green building policy or guidelines and construction training programs. Fourteen of 43 respondents mentioned that they had a green building policy or guideline in their company to guide the company's decisions and actions for their green building projects or programs. The ratio of green building policy or guidelines (14/43) has dramatically increased from 11 out of 87 in 2006 [13]. In addition, eighteen respondents indicated that their company had a green building training program to improve employee's green building knowledge and skills, to identify key practices of green building, to establish competencies in applying LEED and other relevant criteria or established guidelines, to take advantage of financial incentives and technical assistance offered by government, utilities and non-profit organizations, and to work with architects, designers, building operators, and utilities to improve building performance. The ratio of green building training programs has also increased compared to 2006 (17/87) [13]. In addition, respondents running a green building training program indicated that the companies emphasized training their project managers, project engineers, executive members, superintendents and estimators more so than foreman, laborers, and subcontractors.

Eleven respondents indicated that their company currently has a green building division or a green team to manage and support green building projects and LEED certification processes. In the green team and division, project managers, executive members and LEED APs were mainly involved. This outcome supported the 2006 study related to creating a green building team or division because 27 companies out of 75 companies indicated that they would consider creating it.

In addition, 75% of the respondents indicated that their companies had at least one LEED AP and the average number of LEED APs among all companies was 12. In addition, 32 companies offered different types of incentives to motivate their employees to become a LEED AP. The most widely used incentive is that the companies reimburse their employees taking the LEED AP test for the cost of examination. The second most popular incentive was to support employees to attend

green building training programs or sessions. However, the LEED AP accreditation was not reported to influence salary and promotion. These outcomes are very similar to the study in 2006. In addition, one respondent indicated that "LEED AP is not incentivized, it is an expectation."

5.2 Corporate Expectations of New Hires

As green building has gained momentum, it increases the needs for construction managers, architects, and engineers with knowledge and skills in the various aspects of green building [13, 29]. Furthermore, construction-related companies also absorb green building knowledge and skills from incoming employees including university graduates. Therefore, it is very important to identify the construction industry needs related to green building knowledge and skills for new construction graduates. On the basis of construction needs of green building knowledge and skills, construction educators shall create new green building courses and/or integrate those concepts into existing curriculum. Thus, graduates can participate and be valued in the construction workplace, as well as expand traditional means and methods of construction to the new construction paradigm which creates an environmentally responsible, healthy, and prosperous environment.

The next question was to ask company's expected knowledge of green building from their new employees, especially construction program graduates. This question was composed as a closed-end question with multiple-choice where the respondents could pick the best answer or answers from among all the possible options. Four answers extracted from the outcomes of suggested green building topics at the 2006 study were included along with the comment field [13]. The answers included "general knowledge of sustainability in the built environment", "green building rating system", "green building materials, means and methods", "environmental philosophy" and "others (comment field)".

The respondents indicated that "general knowledge of sustainability in the built environment' was the most expected knowledge from construction. In addition, the construction companies also expected construction graduates to have knowledge related to green building rating systems. Comparing between 2006 and 2008 (Figure 7), outcomes indicated that construction companies expects construction educators to teach general knowledge of sustainability in the built environment and green building rating systems even though they have shifted their expectations for the importance of green knowledge from emphasizing green building rating systems to more general knowledge of sustainability in the built environment.

The final question in this section involved the importance of teaching knowledge of sustainability and environment in construction programs. 28% of all respondents believe that the teaching the knowledge of sustainability and environment is very important as a part of construction curriculum. 51% consider it important, while two percent of the respondents believe that construction programs do not need to teach knowledge of sustainability and environment as a part of the curriculum in the future (Figure 8). On the basis of comparing between 2006 and 2008, there has been a dramatic decrease for "neutral" and "not very important" ("Neutral": 31% in 2006 vs. 19% in 2008 and "Not very important": 19% in 2006 vs. 7% in 2008) and a substantial increase for "Important"(Important": 34% in 2006 vs. 51% in 2008). This response supports a dramatic increase in demand for teaching construction students "sustainable knowledge".

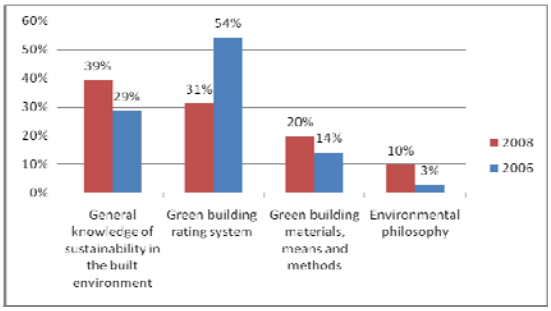

Figure 7. Importance of green knowledge and skills

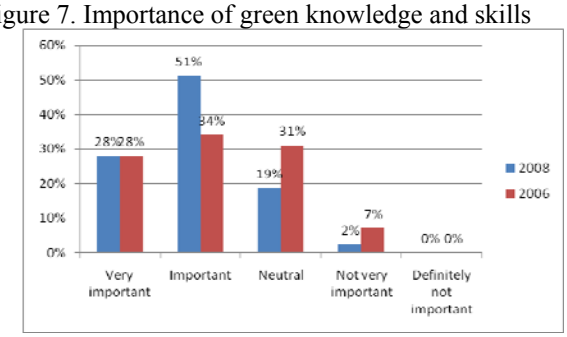

Figure 8. Importance of teaching green building

5.3 Future of Green Building

From analyzing the current status of green building in construction, it is clear that green building is becoming an acceptable way to build in the future and reshape the construction industry. 67% of respondents answered the free response question "How will green building impact the construction industry in the future?". The written responses were clustered into three categories based on content analysis. Only one respondent indicated that green building was limited in the future of the construction industry. 28 respondents specified that green building will be standard practice in the future. From comparing with 2006 outcomes, it seems that construction companies are convinced that green building will become standard practice in the future.

Table 2. Future of green building

Future of green building	Resp. (2008)	Resp. (2006)
Green building will be standard	28	45

practice in the future.	(90%)	(86%)
Sustainable construction will influence practice to some degree	2 (7%)	5 (10%)
Sustainable construction will not be relevant in the future.	1 (1%)	2 (4%)

The next question was to ask about respondents' belief related to cost premiums of green building compared to conventional building practices. This question was very important because many studies have found that the most serious barrier for implementing green building is its perceived increase in initial project costs [13, 43, 44], even though several rigorous studies have demonstrated that green building incurs only marginal cost premiums [21, 45, 46]. In the 2006 study, 61% of respondents indicated that they believe the cost premium of green building will be greater than five percent compared to conventional construction [13].

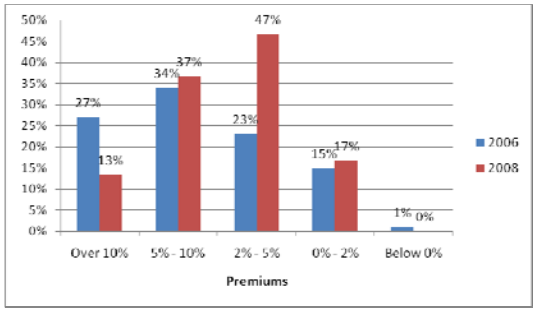

Figure 9. Cost premium of green building with respect to conventional construction

In Figure 9, half of respondents indicated that they believe the cost premium of green building was between 2-5%, and 37% of respondents specified between 5-10% premium. In addition, there was a huge decrease for the range of respondents believing that green building represents a premium of greater than 10%, from 27% in 2006 to 13% in 2008. These outcomes clearly demonstrate that the perception of green building cost premiums is changing with an increase in project experience. This trend further supports the conclusion that green building can become standard practice in the construction industry.

The final open question was to ask respondents about ways to minimize the cost premium of green building. These responses help the construction industry to find ways to address the first cost barrier for implementing green building. Twelve respondents indicated that the way to minimize the cost premium of green building was related to green building materials. Eight respondents indicated that the construction industry needed to increase the size of green building market owner's demand, so that green building becomes a general construction practice. In addition, six respondents pointed out the importance of educating employees, subcontractors, designers and suppliers for green building. Even though the issues of green building materials and familiarity with green building practices have been cause for cost premiums, the lack of education for construction participants also impacts cost premium. Finally, the issue of minimizing paperwork relating to green building was also raised as an issue.

6. CONCLUSIONS

Several conclusions emerged from this study in comparison with the 2006 study. First, green building has strong momentum and is growing into a significant share of the total construction market. Based on the 2006 and 2008 surveys, it is clear that the construction industry actively participates in green building and accumulates knowledge of green building process and practices to minimize negative impacts on our environment and maximize potential social and economic benefits.

Second, 84% of 2008 respondents were found to have some green building project experience in their business. This represents an increase from 68% in 2006, which indicates that green building has more deeply penetrated into the construction industry. In addition, the familiarity of respondents with green building has grown from 2006 to 2008, which also represents an increase by construction professionals in familiarity with green building process and strategies.

Third, the construction industry obtains green building knowledge and skills from conducting internal research and studying trade and professional publications related to green building even though sending employees to green building conferences or seminars and hiring green building consultants are also used for obtain the knowledge and skills of green building. Compared to the 2006 outcome, the construction industry increasingly prefers to obtain green building knowledge and skills through internal research and study rather than attending external conferences or seminars. This transition suggests that construction participants are moving from the adoption of green building to investigating applicable green building strategies and technologies. In addition, companies increasingly offer incentives to motivate their employees to become LEED APs. The most widely used incentive is that the companies supports the cost of the LEED AP exam and sends their employees to green building training programs.

Fourth, respondents indicated that they want to hire construction graduates who have green building knowledge and skills, especially "the basic knowledge and concepts of green building" and "green building rating systems" Furthermore, the construction industry would like construction programs to teach green building rating systems (LEED), general knowledge of sustainability in the built environment, and green building materials and methods to students who study construction so they can be familiar with green building. In addition, construction companies also recognize the importance of sustainable knowledge for construction education.

Finally, construction-related companies' beliefs regarding cost premiums of green building have become

more tempered compared to the findings in 2006. In addition, most respondents believe that green construction will be very important or standard practice in the future. The respondents also recommend minimizing cost premiums of green building by concentrating on green building materials, using common practices, educating construction participants, and minimizing the paperwork related to green building practice.

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